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Galactooligosacharides and Human Health Implications

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Abstract

Galactooligosaccharides (GOS) are non-digestible oligosaccharides which show several physiological properties. The major physiological characteristic is associate with its importance to promote the health of human gut microflora. GOS are formed from concentrated lactose solutions by transgalactosylation reaction of β-galactosidase enzyme. The galactooligosaccharides are prebiotics because promote beneficial effects on microflora and are recognized with the GRAS status. These prebiotics can be incorporated in several products as infant formula, beverages, dairy products, and bakery and confectionary foods. The present mini review aims report about galactooligosaccharides and its relationship with human health.

Keywords: Prebiotics; Bifidobacteria and lactobacilli; GRAS status; Physiological effects; Gut microflora

Abbreviation: GOS: Galactooligosaccharides; TOS: Transgalac-tooligosaccharides; NDO: Non-Digestible Oligosaccharides; FDA: Food and Drug Administration

Introduction

Functional foods have been studied for many researchers around the world principally, due its relationship with benefits positive to health human. The functional foods originated in Japan in the 1980s consist of natural or processed food that contains bioactive compounds and consequently provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease. Among the various functional foods, one of the most important are galactooligosaccharides (GOS), non-digestible oligosaccharides that show as main physiological effect an increase the beneficial microflora of the intestine. GOS are prebiotic and synthetized by the β-galactosidase enzyme, in a reaction known as transgalactosylation. These prebiotics can be used in a variety of food such as infant milk formula, fruit juices, meal replacers, fermented milks, bread and confectionary products. The GOS prebiotics thus, can contribute directly and efficiently with the intestinal flora. This review aimed at pointing to relationship between GOS and implications on human health.

Oligosaccharides

Oligosaccharides, which have from two to ten saccharide units, linked covalently by glycoside bonds in their molecular structure, include maltooligosaccharides and other oligosaccharides [1]. Many oligosaccharides are not digestible by the human organism, others are partially hydrolyzed in the gastrointestinal tract and can result in the formation of essential carbohydrates for health and act as substrates and regulators of the major metabolic pathways [2]. The monosaccharides resulting from this partial hydrolysis are transported through the blood to the liver and later to the systemic circulation. Non-digestible oligosaccharides (NDO) occur naturally in several foods and plant tissues and can be synthesized in the metabolism of animals and microorganisms [3,4]. The oligosaccharides are obtained by extraction of plant tissues, by microbial fermentation, by enzymatic catalysis or by chemical reaction [5]. The physiological and physicochemical properties of its components have been reported as equivalent to dietary fibers, associating their physiological action with important aspects of human health [6]. Due to these properties, oligosaccharides are considered a class of active biomolecules of great importance for human health and are being explored industrially in the development of functional food [4].

Functional Food

The Functional Food Center (FFC) describe that functional food may be natural or processed food with known or unknown biologically active compounds and that provide a clinically proven and documented health benefit for the prevention, management or treatment of chronic disease [7]. Food and Drug Administration (FDA) does not provide a statutory definition of functional foods. At 1990, Nutrition Labeling and Education authorized the FDA to develop regulations for the use of claims on health benefits on foods and dietary supplements, which are often communicated to the consumers through the label on the product, website, or advertising [8]. Functional foods can be regulated as a conventional food, a dietary supplement, a food for special dietary use, a medical food, or a drug and often these distinctions are based depending on the intended use and nature of the claim(s) (e.g., nutrient information and nutrient content and health claims) made on the product. Nutrition and health claims are used to communicate the benefits of functional foods. Within these specifications are the GOS prebiotics.

Galactooligosaccharides (GOS)

GOS, also known as oligogalactosyllactose, oligogalactose, oligolactose, or transgalac-tooligosaccharides (TOS) are non-digestible carbohydrate, resistant to intestinal digestive enzymes with fiber-like effects found naturally in breast milk [9]. Galactooligosaccharides are formed from concentrated lactose solutions by transgalactosylation reaction of β-galactosidase enzyme. β-galactosidase enzyme has similar affinity for both hydrolysis and lactose transgalactosylation [10,11]. The major physiological effect is the selective proliferation of beneficial bacteria especially bifidobacteria and lactobacilli in the gut, which provide resistance against colonization of pathogens thereby reducing exogenous and endogenous intestinal infections [12]. The physico chemical characteristics are associate with water solubility, colorless, viscosity like high-fructose corn syrup, stable to 160 °C for 10min at pH 7; stable to 100 °C for 10 min at pH 2; stable to 37 °Cat pH 2 for several months, reduces the freezing point of foods, humectant properties and sweetness from 0.3 to 0.6 times more of sucrose [13]. By presenting these properties, the GOS can be used in production various foods such as infant formula, beverages, bakery products, pet foods and confectionary products.

Synthesis of GOS

The synthesis of GOS involves three main steps: first, there is the formation of the enzyme-galactosyl complex, followed by hydrolysis of the glycosidic bond β1 → 4 of lactose and the simultaneous release of glucose. Then, enzyme-galactosyl complex is transferred to nucleophilic acceptors containing a hydroxyl group (water or saccharides). In solutions, with low lactose concentration, this acceptor is water, resulting in the formation of galactose. In concentrated lactose solutions, the disaccharide acts as an acceptor and binds to the enzyme-galactosyl complex resulting in the formation of galactooligosaccharides [14]. The rate of GOS production formed is influenced by several factors such as enzyme source, reaction time, pH, process temperature, initial concentration of lactose and the presence of specific inhibitors or activators for the enzyme [15]. In general, and in this case, higher lactose concentration in the medium, higher GOS yield, since, after hydrolysis, the final acceptor of the β-galactosyl group becomes the lactose molecule itself instead of water [16]. The GOS commercially available are founded in liquid or power forms, and are mixtures of several species of oligosaccharides, lactose, glucose and small amount of galactose. In the Japanese market, we can found the Oligomate 55 product which contains at least 55% 4'-GOS The Oligomate commercial products offer mainly GOS with β1→6 linkages; the Bimuno contains mainly β1→3 linkages, Cup-Oligo mainly β1→4 linkages. GOS have a generally reconized as safe (GRAS) status because its components are originated from of human milk and yoghurt and are produced from ingested lactose by resident intestinal bacteria which produce β-galactosidase [17].

GOS and Human Health Implications

GOS show two major benefit to health human: selective proliferation of beneficial bacteria especially bifidobacteria and lactobacilli in the gut, which provide resistance against colonization of pathogens thereby reducing exogenous and endogenous intestinal infections and by production of short chain fatty acids show various beneficial effects including reduction of cancer risk, increase in mineral absorption, improvement in bowel habit, control of serum lipid and cholesterol level, and reduce cancer risk and IBD inflammation [18,19]. GOS are included among non-digestible oligosaccharides (NDOs) that have prebiotic properties and are licensed as FOSHU (Foods for Specified Health Use) food additives by the Japanese Ministry of Health [19]. In the late 1970s, the use of GOS as substitute milk oligosaccharides in infant formulas was proposed with the aim of promoting healthy intestinal microflora [19]. Many studies have reported about the GOS potential in human health promotion. Scholtens et al. [20] administered galactooligosaccharide and fructooligosaccharide (FOS) doses to 38 infants for 6 weeks and demonstrated the increase of bifidobacteria in the intestinal microbiota. Bruzzese et al. [21] also performed a study with 342 infants using GOS and FOS (0.4g/100mL/day) and reported the reduction of respiratory and intestinal infections during the first year of life. Vulevic [22] evaluated the ability of GOS to reduce markers of metabolic syndrome. Forty-five volunteers with overweight and three risk factors

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for the syndrome were selected. In a double-blind study, volunteers ingested 5.5g/day of GOS for 6 and 12 weeks, control was performed with placebo. The author concluded that ingestion of GOS increased the population of bifidobacteria and decreased bacteroides and Clostridium histolycum when compared with placebo. Musilova et al. [23] evaluated the effect of the combination of GOS and maltodextrin in vitro by incubating in fecal samples, and in vivo by administration of maltodextrin in healthy adults, followed by analysis of the microbiota fecal. In the in vitro test, a greater amount of bifidobacteria was observed. In the in vivo analyzes, the increase of fecal bifidobacteria was approximately 30 % and the reduction of Escherichia coli was around 20%. Thus, the authors concluded that the mixture of GOS and maltodextrin promoted bifidogenic properties, promoted the growth of bifidobacteria and inhibited the development of undesirable bacteria. A recent study, Perdijk et al. [24] investigated the effects of the human milk oligosaccharides (HMO) sialyllactose (SL), and galactooligosaccharides (GOS) on epithelial barrier functioning, microbiota composition, and short chain fatty acids (SCFA) production and concluded SL and GOS did show distinct modulation of microbiota composition, promoting the outgrowth of Bacteroides and bifidobacteria, respectively, which resulted in distinct changes in SCFA production profiles.

Conclusion

This article provides a mini review about galactooligosaccharides and its relationship with human health. The galactooligosaccharides (GOS) are non-digestible oligosaccharides and synthetized by β-galactosidase enzyme in a reaction known as transgalactosylation. GOS are prebiotics that show as major physiological effect because alter the balance of the large bowel microbiota by increasing bifidobacteria and Lactobacillus number. These prebiotics are recognized as GRAS status and then, can be used in a several foods including kid's formula milk, fermented milk, confectionary products, breads and others.

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